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PLANNING THE CONVERSION

TO ELECTRONIC DATA PROCESSING.

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PREFACE

As the leader and pioneer in the use of electronic data processing equipment, the Federal Government has slowly developed broad guidelines for planning for the utilization of electronic data processing equipment, and these guidelines are of value to an organization contemplating conversion to electronic data processing. This paper traces the development of the planning factors and considerations which make up the requirements for conversion to electronic data processing. Most of the research material utilized was from surveys and studies conducted by the General Accounting Office, Bureau of the Budget, or the Department of the Navy. Detailed studies of specific problems of converting to electronic data processing encountered by firms in private industry were not available.

The two major phases of planning—the preliminary study and systems study—are the basic framework upon which to build the conversion to electronic data processing. These studies are an assurance for orderly conversion in which the minimum disruption and minimum cost, as well as maximum effectiveness, can be attained in the shortest possible time. Although these studies require months or years of participation by all levels of management, the studies more than pay their way as the new structure of organization and development.

D.W.B.

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CHAPTER I

HISTORY OF THE DEVELOPMENT OF COMPUTERS

Less than twenty-five years ago, the first computers were developed and applied to scientific problems. These computers, in common with all computers, consisted of input and output devices, storage, arithmetic, and comparison units, and a control unit.[1] Early computers were able to do immense amounts of mathematical calculation, which was ideal for scientific and engineering applications. In these applications, the amount of information which was put into the computer, the input, was very small. Also, the amount of information which was produced by the computer, the output, was very small. However, the amount of calculations and comparisons that could be made within the computer's arithmetic and logic units was immense and rapid.[2] Criteria for installation of this type computer were largely determined by the amount of complex calculations which had to be made. Only limited planning was required prior to installation because of the specialized function of the computer. Further developments in scientific applications led to the completion in 1945 of the Electronic

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[1] U. S. Bureau of the Budget, Automatic Data Processing Glossary (Washington, D.C.: U. S. Government Printing Office, 1962), p. 12. Cited hereinafter as Bureau of the Budget, ADP Glossary.

[2] U. S. Department of the Navy, Navy Data Processing Program, Secretary of the Navy Instruction P10462.7 (Washington, D.C., 1959), p. II-1. Cited hereinafter as Department of the Navy, Data Processing Program.

Numerical Integrator and Calculator [ENIAC]. This was the first large-scale, high speed, all electronic computer.[1] Attempts were made to use these computers to solve business and management problems, but the basic differences in business problems and scientific problems exceeded the computers' capabilities. While scientific problems were characterized by a small amount of input and output and a large amount of calculation, business problems were characterized by a large amount of input and output and a small amount of calculation.[2] ENIAC led to the development of further refinements and, in 1951, to the development of the Universal Automatic Computer [Univac].[3]

Initial Business Applications

Except for crude applications to logistic and supply types of work, the electronic computer was limited to scientific applications until the development of Univac I, the first electronic computer system for commercial or business purposes.[4] This system was installed in the U. S. Bureau of the Census, in which it was utilized for over twelve years.[5] At the time of Univac I's installation in the Bureau of the Census, it was estimated that the potential world market for this type computer was a total of six.[6] Univac I was huge in size and required an immense amount

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[1]Richard N. Schmidt and William E. Meyers, Electronic Business Data Processing (New York: Holt, Rinehart, and Winston, 1963), p. 14.

[2]Department of the Navy, Data Processing Program, pp. II-2, 3.

[3]Schmidt and Meyers, pp. 14-15.

[4]Ibid., p. 12.

[5]Jack Morton, Presentation in IBM Customer Executive Program, Washington, D. C., January 25, 1965.

[6]Ibid.

of air conditioning. Use of vacuum tubes limited the reliability and caused high maintenance costs. Even though Univac I possessed these limitations, it processed the information in the 1950 Census faster and with increased accuracy in relation to the prior electromechanical method of handling data. The electromechanical or tabulating equipment consisted of card punch machines for punching, sorting, listing, and totaling data on punch cards.[1] The use of electromechanical equipment in connection with an electronic computer so as to reduce the need for human intervention to a minimum is referred to as "automatic data processing" [ADP].[2] When this information processing is "performed largely by electronic equipment" it is referred to as "electronic data processing" [EDP].[3] Increased storage capacity, "the number of elementary pieces of data that can be contained in a storage device,"[4] as well as increased input and output, greatly increased the versatility of the Univac I, which was capable of solving business and management control problems.

Later Computer Developments

Discovery and development of the solid-state conductors and of new methods to increase internal and external storage led to a wide range of equipment for general and specific operations. "Solid-state conductors" are defined as,

> the electronic components that convey or control electrons within solid materials; e.g., transistors, germanium

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[1] Bureau of the Budget, ADP Glossary, p. 21.

[2] Ibid., p. 40.

[3] Ibid.

[4] Ibid., p. 6.

> diodes, and magnetic cores. Thus vacuum tubes and gas tubes are not included.[1]

Use of solid-state devices in computers resulted in such marked advances that these computers became known as "second-generation." The transistor took only about a tenth of the space and a fraction of the power required by the vacuum or gas tube. Heat generation was greatly reduced by substituting transistors for tubes. When the new solid-state computer is compared to the ENIAC, which had between thirteen and eighteen thousand tubes, it is easy to imagine how the solid-state computer is greatly reduced in size, requires far less air-conditioning, power, and maintenance, and is more reliable.[2] Another solid-state device, the magnetic core, helped to greatly increase the internal storage capacity or memory of the computer. "Internal storage" is defined as,

> the storage facilities forming an integral physical part of the computer and directly controlled by the computer. In such facilities all data are automatically accessible to the computer.[3]

This increase in internal storage capacity enabled both input and output to be increased. Development of external storage in the forms of magnetic cores, magnetic discs, and magnetic drums as well as improved utilization of magnetic tape provided a variety of equipment to meet particular needs. Other peripheral equipment, "auxillary machines which may be placed under the control of the central computer,"[4] was being developed for a wide

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[1] Ibid., p. 50.

[2] Morton.

[3] Bureau of the Budget, ADP Glossary, p. 51.

[4] Ibid., p. 21.

variety of purposes. This peripheral equipment could be "used on-line or off-line, depending on the computer design, job requirements and economics."[1] "On-line" is defined as being under the control of the central computer or central processing unit so that "information reflecting current activity is introduced into the data processing system as soon as it occurs,"[2] whereas "off-line" is defined as "descriptive of a system and of peripheral equipment or devices in a system in which the operation of peripheral equipment is not under the control of the central processing unit."[3] With these changes in computer capabilities and limitations, the various Federal agencies and departments started experimenting with the application of electronic data processing to supplement and replace manual and electromechanical methods of data processing in business and management control systems.

Growth of Requirements for Planning

As more funds were budgeted for automatic data processing installations in the Federal Government, a special survey in 1957 by the General Accounting Office revealed basic weaknesses and strengths in planning for utilization of this new tool of management.[4]

This survey reported that by the end of 1957 the number of electronic computers in business applications in the Federal Government was

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[1] Ibid.

[2] Ibid.

[3] Ibid., p. 36.

[4] U. S. Comptroller General, A Special Report to the Congress of the United States, Survey of Progress and Trend of Development and Use of Automatic Data Processing in Business and Management Control Systems of the Federal Government as of December 1957 (Washington, D.C.: U. S. Government Printing Office, 1958), p. 11. Cited hereinafter as Comptroller General, Survey of Progress.

one hundred twenty-one. Over one-half of these installations were in the supply and logistics area. Personnel and financial accounting were the other principal areas of utilization. The phenomenal growth rate along with the attendant cost—over twenty-nine million dollars—caused concern as to the way in which this tool of management was being utilized.[1] Different computer applications on the same basic problem revealed not only different methodology but sharply contrasting results. Although some difference was to be expected, since the very early applications were more in the nature of research and development projects, the later applications by different agencies to the same basic problem yielded differences in methods, costs, and effectiveness. In some cases the higher costs were associated with less effective installations.[2]

Realization of the need for systematic planning of the computer installation was one of the conclusions of the 1957 Survey by the General Accounting Office. They reported on many of the feasibility studies conducted by the various agencies; the term "feasibility study" was used to designate the initial planning phase or preliminary study.[3] In other reports by the General Accounting Office the term "feasibility study" was used to include both the preliminary study and the system study.[4]

This difference in the broad and narrow meanings of "feasibility study" may have been the reason the Bureau of the Budget adopted the terms

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[1] Ibid., pp. 2-3.

[2] Ibid., pp. 24-25.

[3] Ibid., p. 61.

[4] U. S. Comptroller General, Report to the Congress of the United States, Review of Automatic Data Processing System at the Transportation Material Command, Department of the Army, St. Louis, Missouri (Washington, D. C., 1960), p. 32. Cited hereinafter as Comptroller General, Review of Transportation Material Command.

"probability study" for the preliminary study, and "system study" for the detailed system analysis.[1]

Realization of the need for planning a new organizational structure to attain the full benefits of the computer was another of the conclusions of the 1957 General Accounting Office Survey. The study also recognized that the manual, machine, and electromechanical methods should be used with the electronic computer where each has the comparative advantage.[2] No one will quarrel with the statement that "It is important that the most suitable equipment be obtained if the operation is to be most efficient."[3] But how can the "most suitable" mix of equipment be determined? The only way to arrive at a close approximation is through planning, not merely planning of every detail of a modified system but planning a new system based on the information required to perform the mission and to meet the requirements of higher authority. This detailed plan is preceded by a study, and even such a study should be thoroughly planned for maximum effectiveness.

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[1] U. S. Bureau of the Budget, Guidelines for Appraising Agency Practices in the Management of Automatic Data Processing (ADP) Equipment in Federal Agencies, Bureau of the Budget Circular No. A-61 (Washington, D. C., 1963), p. 2. Cited hereinafter as Bureau of the Budget, Circular No. A-61.

[2] Ibid., p. 8.

[3] Ibid., p. 9.

CHAPTER II

PLANNING FOR THE PRELIMINARY STUDY

In the conversion from manual or electromechanical data processing to electronic data processing, the first step is generally a review of the management information system. Such a review has been called a preliminary study, preliminary analysis, probability study, or feasibility study. Its main purposes are to determine the information requirements of an organization and to determine the probability that changes in the present system will result in less cost or improved management effectiveness.[1] Due to the time, cost, and complexity of a detailed systems analysis, determination of the "overall soundness of applying ADP to the operations" begins with a preliminary study.[2] Three responsibilities of the top manager in planning a preliminary study are selection of area and objectives, appointment of members of the study group, and formulation of a program to insure support at all levels.

Selection of Area and Objectives

In selecting the area for study, past experience has shown that areas of fruitful application of automatic data processing have been characterized by at least one of the following:

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[1] Department of the Navy, Data Processing Program, p. IV-3.

[2] U. S. Bureau of the Budget, Automatic Data Processing (ADP) Program of the Executive Branch: Studies Preceding the Acquisition of ADP Equipment, Bureau of the Budget Bulletin No. 60-6 (Washington, 1960), p. 2. Cited hereinafter as Bureau of the Budget, Bulletin No. 60-6.

a. Large volume repetitive operations.
b. High clerical costs.
c. Complex computational problems.
d. Urgent time scheduling factors.[1]

Selection of the area for study may be limited to a specific operation, may be a general activity which cuts across functional lines of the organization, or may be the total organization. A drawback to selection of a specific operation as the area of study is that it often leads to automation of existing procedures; whereas, study of a general activity or the total organization is more apt to integrate closely related information and processing procedures. The area of study might well be the total information flow within the organization, which is more in accord with the General Accounting Office's goal of master planning for an integrated information processing system.[2]

Within the area of study designated by the top manager, the objectives are simplification of information flow and improvement of management effectiveness. These objectives include the analysis of the broad, over-all information flow pattern in terms of management needs.[3] The ultimate objective is to determine whether or not an electronic data application would result in reduced costs or increased management effectiveness.

Appointment of Members

Another critical area in planning the preliminary study is selection and appointment of members of the study group. Appointment from top

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[1] Ibid., p. 1.

[2] Comptroller General, Survey of Progress, p. 37.

[3] Department of the Navy, Data Processing Program, p. IV-3.

levels of management will help prevent a parochial point of view and insure thorough performance of the task. All major areas and functions should be represented on the study group to insure familiarity with all operational and management needs of the activity. Some members of the study group must have a background in systems analysis and management engineering techniques, and some must have a knowledge of the capabilities and limitations of data processing equipment.[1] Functional lines will be crossed as the information system study progresses, and the foregoing membership will be qualified to evaluate proposed system and organization modifications.

Service on the study group is more effective on a full-time basis. It is preferable that the study group be smaller in size and serve full-time rather than be a large part-time study group. The leader must serve full-time even if other top level personnel can only be spared for part-time participation. Completion of the study generally takes from two to three months, and this may be too long a period to have a number of top level personnel away from their regularly assigned duties. However, part-time participation of top level personnel is preferable to "full-time participation of more provincially oriented lower level personnel."[2] Use of top level personnel also helps to solve the problem of management support.

Program for Support

Part of the planning for the preliminary study is the formulation of a program to insure support for the preliminary study and for the

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[1]Bureau of the Budget, Bulletin No. 60-6, 1960, p. 4.

[2]Department of the Navy, Data Processing Program, p. IV-3.

detailed systems analysis which may follow. The use of top level personnel of the study groups helps to gain the participants' support, but this assignment can be supplemented with briefings, discussions, and orientation courses for all top level personnel.[1] One recent statement concerning the need for top management support was:

> This management system can survive and will operate successfully in spite of stupidity, meager resources, and human error. These deficiencies are correctible. This system will definitely not work or survive in an atmosphere of indifference and especially an atmosphere created by command indifference.[2]

They can gain in understanding the magnitude of the problems involved and can be motivated to be more willing participants if the preliminary study results in a systems study. During the systems study, some middle-management resistance is generated by the demand for precise, written definitions of all instructions and procedures and by the revelation of weaknesses and deficiencies.[3] A part of the support program can be the formulation and publication of an employee relations policy to reduce the uncertainty and fear of job security, which often arises as a preliminary study is undertaken. An employee relations policy of training present employees as programmers and operators and using attrition rather than reduction-in-force procedures has proved successful in calming the fears of job security.[4]

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[1] Bureau of the Budget, Bulletin No. 60-6, 1960, p. 2.

[2] U. S. Department of the Navy, Naval Aviation Maintenance and Material Management Manual (Washington, D. C., 1964), p. I-21.

[3] Department of the Navy, Data Processing Program, p. II-7.

[4] Ibid.

The policy that personnel adjustments which result from machine applications will be minimized by training, attrition, or reassignment in preference to reduction-in-force procedures can be publicized in both the formal and informal publications of the organization. Preferably, publication should commence at the time of the first briefings and discussions, but it should commence prior to the completion of the preliminary study. The importance of keeping employees fully informed to obtain their full support should not be underestimated.

Reporting Requirements

The final, written report should be as brief and factual as possible and should include benefits from redesign of the information system, barriers caused by external regulations, and recommendations for redesigning the system and removing the barriers where appropriate. If the acquisition of ADP equipment is recommended, the report should include a description of the application, the benefits to be derived, an indication of the size and type of equipment, a cost comparison of the present and proposed systems, a recommendation to proceed with a systems study, and a time table for further development. All of the assigned objectives of the study should be answered with positive recommendations in the report, which should go directly to the top manager who ordered the study. The foregoing requirements should be incorporated into the appointment letter along with a definite reporting date. Not more than two to three months should be required to complete a preliminary study except for the most complex activities.[1]

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[1] Ibid., pp. IV-3, 4.

After the foregoing policies, decisions, and appointments have been made, the stage is set for conducting the preliminary study.

CHAPTER III

CONSIDERATION IN CONDUCTING THE PRELIMINARY STUDY

Conducting the preliminary study can be divided into three basic steps: (a) determination of the cost of present data handling procedures, (b) determination of information essential to effective management, and (c) determination of impact of a change in data processing methods upon the organization.

Information Flow Outline

Prior to studying the existing information system, the members appointed to conduct the preliminary study can begin by reviewing the objectives and scope outlined in their appointment letter and by attending the briefings, discussions, and orientation scheduled by top management (all of which were discussed in the preceding chapter). With a common understanding of the objectives, the group can begin to outline the present information flow within the organization. Outlining the present system will be aided by the preparation of a flow chart. This is defined as:

> a graphic representation of the major steps of work in process. The illustrative symbols may represent documents, machines, or actions taken during the process. The area of concentration is on where or who does what rather than how it is done.[1]

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[1] Bureau of the Budget, ADP Glossary, p. 8.

Such an outline can then be divided into functional or major operational areas to show what information is generated and processed. The reason for preparing the outline of the present information flow is to determine the significant cost elements such as man-hour effort associated with each function or major operation.[1]

Information Requirements Analysis

The second step is the determination of the information requirements or the information essential to effective management. Information requirements are defined as "the actual or anticipated questions which may be posed to an information system."[2] In determining the information requirements, a systematic analysis of data from the viewpoint of effective management of the various operations is necessary. Suggested starting points for analysis are "unmanageable backlog, those operations which are the most costly, take the most time, or are presently mechanized."[3] However, care must be exercised in the analysis so that the results do not become a mere substitution of an electronic computer for performing work under the old manual or electromechanical methods. Analysis should be made with the view of seeking the optimum method of accomplishing the tasks and of expediting the workload. Also, care must be exercised in determining whether an operation or report is authorized or essential to mission accomplishment. This analysis is one of the areas in which the combination of data, reports, or functions, or, better yet, the elimination of data, reports, or functions, can result in real savings. As Peter F. Drucker has said:

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[1]Bureau of the Budget, Bulletin No. 60-6, p. 2.

[2]Bureau of the Budget, ADP Glossary, p. 45.

[3]Bureau of the Budget, Bulletin No. 60-6, pp. 2-3.

> The one truly effective way to cut costs is to cut out an activity altogether. To try to cut back costs is rarely effective. There is little point to trying to do cheaply what should not be done at all.[1]

Reduction in data, reports, or operations may make a difference in the size, if any, of the computer required. A basic principle to follow is that of using a comprehensive approach to outline an ideal system with a minimum of emphasis on current organization.[2] Long-range goals of the organization should be given the primary emphasis, and due consideration should be given to the plans and programs of each division. In commenting on an ADP installation in the Department of the Interior, the General Accounting Office noted that careful consideration of the plans and programs of each division was accomplished early in the study and that technical and administrative personnel from all divisions of the organization were in the study group.[3] The Navy also stressed the need for anticipating changes in organization and procedures and implementing the changes at the earliest, practical time.[4] Consideration of the information requirements not only includes the determination of what data is required but the frequency at which it is required, and the speed at which it is required. In some cases the necessity for speed will outweigh the consideration of economy.[5]

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[1]Peter F. Drucker, Managing for Results (New York: Harper & Row, Publishers, 1964), p. 69.

[2]Department of the Navy, Data Processing Program, p. II-5.

[3]U. S. Comptroller General, Report to the Committee on Post Office and Civil Service, House of Representatives, Review of Automatic Data Processing Installation, Geographical Survey, Department of the Interior, October, 1959 (Washington, D. C., 1959), pp. 4, 7. Cited hereinafter as Comptroller General, Review of Geological Survey.

[4]Department of the Navy, Data Processing Program, p. II-5.

[5]Bureau of the Budget, Bulletin No. 60-6, p. 3.

Once the information requirements are determined, an examination of available source data is necessary to establish whether or not sufficient source data are available to meet all of managements' requirements. In some cases there will be a duplication of source data, and duplication of data can be eliminated in most cases. If some required source data are not available, then a determination should be made as to the optimum method by which it can be obtained. After all of the information requirements have been determined, the decision can be made as to the type of data processing system that will be most appropriate.

Nature and Degree of Impact

The final step in conducting the preliminary study is the determination of the nature and degree of impact that changes in the data processing methods will produce. Recommended changes in procedures, functions, or organization should be supported with estimates of the effect on personnel and organization. Significant improvements in procedures resulted from preliminary studies conducted by the Air Force and were independent of the use of computers.[1] The Navy also reported some improvement in procedures due to preliminary studies and independent of the use of computers.[2] Redesigning the information and reporting system on the basis of the management-by-exception principle may yield tangible benefits. The "exception principle system" is defined as, "an information system or data processing system which reports on situations only

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[1]Comptroller General, Survey of Progress, pp. 99-100.

[2]Ibid., p. 111.

when actual results differ from planned results. When results occur within a normal range they are not reported."[1]

The areas which are susceptible to immediate conversion to automatic data processing can be separated from those susceptible to ultimate conversion in the over-all plan. For areas susceptible to immediate conversion, available aid to review and subsequent planning is an estimate of the cost and of the length of time required for each of the following:

1. Computer (including size) (rental or purchase plus maintenance)
2. Site Preparation (including building modifications, power cables, raised flooring to cover cables, soundproofing, airconditioning)
3. Installation of Computer
4. Conversion of records and filed (data clean-up and transition)
5. Systems study
6. Programming
7. Training of Personnel
8. Number and Level of Personnel
9. Testing of Program
10. Dual Operation of old and new system (Parallel operation)

The total of the cost estimates can be compared with the available resources to determine whether or not adequate funds are available. In a case study of the Electronic Supply Office, Bayonne, New Jersey, the basic purpose of each internal review of the data processing system was "to obtain the greatest possible increase in system capacity at the time (or nearly the same) operating cost as the existing system."[2] It was pointed

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[1]Bureau of the Budget, ADP Glossary, p. 54.

[2]Bureau of the Budget, Automatic Data Processing Case History, Department of the Navy, Electronic Supply Office, a case study prepared by Harbridge House, Inc., Boston (Washington, D.C.: U. S. Government Printing Office, 1964, p. 140.

out that the foregoing cost and capacity approach reduced the alternative to equivalent cost terms and thereby minimized the time and cost of planning and review.

Determination of the over-all effects on the organization, procedures, and personnel due to utilization of ADP are generally the last estimations in the preliminary study.

In the placement of the ADP unit within the organization, it has been more satisfactory to have central control of the ADP unit than to have control exercised by one of the functional users. In the General Accounting Office's review of the Geological Survey, the General Accounting Office commented on the appropriateness of the preliminary study group's recommendation to move control of the ADP function from the Office of Budget and Finance to the Administrative Office, since the proposed use would be mainly from the technical offices rather than from the accounting branch as in the past.[1] There is a need for central authority at a high level to coordinate the organization-wide data processing program and to stimulate planning which crosses organizational lines. This central authority can be more effective as a high-level planning group than as an operating group.[2]

The effects of organizational changes will also have an influence on procedural and personnel changes. An estimate of the numbers and level of employee changes should be included. All of the foregoing information has been sought and analyzed to determine "whether new equipment with an

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[1]Comptroller General, Review of Geological Survey, p. 7.

[2]Bureau of the Budget, Circular No. A-61, p. 1.

appropriate system will be more efficient than the present data-processing system."[1]

In their review of the Transportation Material Command, the General Accounting Office stated that an effective preliminary study should encompass:

1. A critical review of the goals the organization has set out to reach.
2. A detailed study of how the present work effort is utilized to reach these goals, including a realistic examination of necessary reporting requirements.
3. The development of an ideal system or master plan for attaining these goals.
4. A study of how computer equipment can be used to achieve all or any economical portion of this ideal system.
5. A technical study of the characteristics and potential of data processing equipment which will meet the data processing needs of the agency.
6. A realistic examination of the cost of such equipment when related to the results that can be attained.
7. Written recommendations to top management as to the course of action that should be taken.[2]

This list of requirements may be broader than those generally associated with a preliminary study but it appears to be an effective guide. The last item on this guide states the requirements for written recommendations to top management, and the prior items imply a depth of study which would require documentation. In Bureau of the Budget Circular A-54, the

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[1]U. S. Comptroller General, Report to the Congress of the United States, Review of Automatic Data Processing Activities at Department Headquarters and at the New York and Richmond Offices, Post Office Department March 1961 (Washington, D. C., 1962), p. 17. Cited hereinafter as Comptroller General, Review of Post Office Department.

[2]Comptroller General, Review of Transportation Material Command, p. 32.

requirement is stated that each significant step in the process of deciding to convert to ADP should be sufficiently documented to show the considerations and basis for decisions.[1]

The final, written report should be as brief and factual as possible and, if use of ADP equipment is recommended, should include a time table for the systems study, selection of equipment, and conversions.[2]

If the recommendation for conversion to ADP equipment is approved by higher authority, the system study can proceed.

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[1]U. S. Bureau of the Budget, Policies on Selection and Acquisition of Automatic Data Processing (ADP) Equipment, Bureau of the Budget Circular No. A-54 (Washington, D.C., 1961), p. 5. Cited hereinafter as Bureau of the Budget, Circular No. A-54.

[2]Department of the Navy, Data Processing Program, p. IV-4.

CHAPTER IV

SYSTEMS DESIGN AND SPECIFICATIONS

A successful systems study is based on participation of top management, on familiarity with the needs of the organization, and on knowledge of and applications of principles of management engineering. The systems study objectives are to design a basic system and to develop specifications for that system. "Systems analysis" is defined as: "the examination of an activity, procedure, method, technique, or a business to determine what must be accomplished and how the necessary operation may best be accomplished."[1]

In the report on the Post Office Department, the General Accounting Office stated that, ". . . as a general rule, a complete systems analysis or functional survey of existing procedures should be made with a view towards streamlining and improving operations before action is taken to utilize large-scale ADP equipment."[2] One of the first considerations in the study is that of management support.

Top Management Support

One of the highly publicized needs is that of top management support through every stage of the conversion to automatic data processing.

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[1]Bureau of the Budget, ADP Glossary, p. 2.

[2]Comptroller General, Review of Post Office Department, pp. 17-18.

This was discussed previously in chapter II but is worth some amplification. One of the reasons for failing to realize the potential in a management information system was the inadequate effort put forth by top management.[1] In the 1957 Survey of ADP, the Comptroller General pointed out that the participation and full support of top management were absolutely essential for the development of an effective computer installation.[2] The attention and interest of top management, which is an essential ingredient, should be apparent in the appointment of the members of the systems study group.

Systems Study Group

Representatives of every major division and function of the organization should be appointed to the systems study group along with personnel with systems analysis or management engineering experience. The systems study group can be the same group that conducted the preliminary study but expanded by additional appointments to handle the larger, more detailed task. The same considerations discussed in chapter II on selecting members for the preliminary study group are required in selecting the members of the systems study group. In the 1960 Survey of ADP, the Comptroller General reprinted the recommendations of the House Subcommittee on Census and Government Statistics that once a decision is made to utilize electronic data processing equipment, personnel officials should be made a part of the planning group.[3]

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[1]John F. Garrity, "The Management Information Dream: The End or a New Beginning?" Financial Executive, XXXII, No. 9 (September, 1964), 14.

[2]Comptroller General, Survey of Progress, p. 27.

[3]U. S. Comptroller General, Report to the Congress of the United States. Review of Automatic Data Processing Developments in the Federal Government (Washington, D. C., 1960), p. 84. Cited hereinafter as Comptroller General, Review of Developments.

Another factor in appointing the systems study group is that units, functions, or activities identified in the preliminary study as being affected by ADP should be represented to insure that their needs will be met.[1] As Neil Ulman said, "All that engineering and equipment doesn't mean a thing unless you have people able to understand and interpret it in terms of customer needs."[2] The need for people who are familiar with systems analysis, management engineering techniques, and computer capabilities is also stressed in much of the literature written about automatic data processing. Successful application turns less on the capabilities of a particular machine system and more on the ability of systems analysis or management engineers to discover new organizational designs and methods of application. The reasons for the shift in emphasis from knowledge of computer capabilities to knowledge of systems design are that the computers for business application are general purpose in character and the difference in computers and peripheral equipment of different manufacturers is decreasing markedly. The information flow pattern, which consists of data origination, storage, and retrieval, cannot be "uneconomically redundant and parochial in emphasis if the organization as a whole is to benefit."[3] Optimization of the information flow pattern can be materially aided by systems analysts or management engineers.

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[1]U. S. Department of the Navy, Department of the Navy Automatic Data Processing Equipment (ADPE) Program, Secretary of the Navy Instruction P10462.7A (Washington, D. C., 1964), pp. C-2, 3. Cited hereinafter as Department of the Navy, Equipment Program.

[2]Neil Ulman, "New Jobs for Computers," Management Review, XXXXXII, No. 7 (July, 1963), 28.

[3]Gerald G. Fisch, "The Integrated Management Organization," Financial Executive, XXXII, No. 5 (May, 1964), 16.

Basic Principles of Systems Design

Among the important basic principles of systems analysis and design are uniformity of approach, utilization of machine logic, integration of processing, capitalizing on the capabilities of the computer and management by exception.[1] The principle of uniformity of approach is essential to all phases of the study, if the facts developed and recorded are to be comparable with other phases or to facts gathered and analyzed in the same phase by different members of the study group.[2] A plan for a uniform method of recording facts and of developing findings will help insure a common approach and comparable data.

Closely related to the principle of uniformity of approach is the principle of applying machine logic to the present system when recording facts. Machine or computer logic is very narrow, and the computer only reacts to a very narrow set of stimuli.[3] This restriction reveals that one of the most difficult problems in conversion to electronic data processing is the preparation of the question and the handling of the answer by the computer. Use of flow charts to show the number, frequency, and relationship of one document to another and to the different units within the organization will facilitate preparing a detailed description of the present information processing system.[4] Such a detailed description should reveal what is done, how it is done, where it is done, and when or how often it is done. Distinguishing between how management thinks things are being done and how they are actually being done is a major problem in analysis of the

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[1] Bureau of the Budget, Bulletin No. 60-6, pp. 5-6.

[2] Ibid., p. 5.

[3] L. R. Fiock, Jr., "Seven Deadly Dangers in EDP," Harvard Business Review, XXXX, No. 3 (May-June, 1962), 89.

[4] Bureau of the Budget, Bulletin No. 60-6, p. 4.

present system.[1] If possible at this stage, the use of Common Business Oriented Language [COBOL] in describing and flow-charting the present system and in designing the new system will be a great aid in later programing.[2] The principle of utilizing computer language at the earliest possible time in describing the present system is also applicable to the system which is to be developed. Conversion of source data to machine language "in the ideal process would be the simultaneous preparation of the source document and of the input data in machine intelligible language."[3] Use of the same source document or item of information by several departments brings to mind the interrelated principles of integration of closely related activities and of capitalizing on machine capabilities. Maximum integration of data processing is achieved by reducing or eliminating duplicate data entries or processing steps and is exemplified by combining personnel, payroll, and cost accounting information so that one document serves these multiple uses. This procedure also involves the principle of capitalizing on the capabilities of the computer in that it eliminates intermediate documents and manual data handling and utilizes one source document as inputs to three separate outputs or reports.

Attempting to integrate closely related data processing and to capitalize on the capabilities of the computer generally leads to reorganization. The trend towards decentralization can be reversed due to the ease offered by computers in assembling data in a central location and to the

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[1] Flock, p. 90.

[2] Bureau of the Budget, Bulletin No. 60-6, p. 5.

[3] Ibid.

speed with which the data and subsequent instructions can be transmitted.[1] Centralization of field activities or functions can prevent costly duplication of facilities and staffing. In the review of the Kansas City and Evanston Commodity Offices, the General Accounting Office pointed out that the centralization of one function eliminated the duplication in staffing and programing, but that the same amount of equipment was required. Closely related to the number of functions is the number of levels within a function or an organization. Information distortion and delay can be the result of too many levels in the management hierarchy,[3] and electronic data processing offers an opportunity to reduce the distortion and delay as well as the number of levels in the management hierarchy. Opportunities for effective organizational changes are illustrated in the case study of the Navy Finance Center in Cleveland. "Approximately one-half of the total organization structure of the Center either had to be redesigned or was affected in a major way" by the shift from electromechanical equipment to electronic equipment at the Navy Finance Center, Cleveland.[4]

Another basic principle to be considered is that of management by exception. This principle is practiced to a limited degree in any

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[1]George Kozmetsky and Paul Kircher, Electronic Computers and Management Control (New York: McGraw Hill Book Company, Inc., 1956), p. 3.

[2]U. S. Comptroller General, Report to the Congress of the United States, Inadequacies in Planning and Operation of Electronic Data Processing Systems at the Kansas City and Evanston Commodity Offices, Agricultural Stabilization and Conservation Service, Department of Agriculture (Washington, D. C., 1963), pp. 8-9. Cited hereinafter as Comptroller General, Review of Kansas City and Evanston Commodity Offices.

[3]Henry H. Albers, Organized Executive Action: Decision-Making, Communications, and Leadership (New York: John Wiley & Sons, Inc., 1962), p. 345.

[4]E. K. Auerbach, "Applied ADP in Financial Management," Presentation to the U. S. Civil Service Commission, Washington, D. C., February 4, 1965.

organization, but its application becomes a necessity when converting to EDP due to the vast amount of information which the computer is capable of including in its output. The computer output, print-out, or report can be so voluminous that there is insufficient time to analyze it and determine what information is significant. As has been frequently pointed out, the computer can smother "management under a mass of detail that tends to create only confusion rather than enlightenment."[1] Planning and programming so that only significant variations from normal are printed out will save management's time as well as computer time.[2] However, provision for a complete report may be necessary for an audit or as a reference. Use of these basic principles in outlining the present system and in designing a new system will aid in producing an optimum system.

Development of Basic System Design and Specifications

Basic systems design is dependent upon determination of objectives, output requirements, input requirements, transaction handling, and information maintenance. Starting with the objectives or the end sought by the organization helps in evaluating each process, function, or procedure's contribution or hindrance in accomplishing the objective. Concentrating on the objective helps to shift the area of planning to "What should it be?" from "What is it?" Focusing on internal information and past events has been listed as one of the main reasons for failing to realize the potential in an automated information system.[3] Another widely recognized reason for

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[1] J. H. Schlosser, "An EDP Application That Gives Information Plus," The Controller, XXX, No. 11 (November, 1962), 548.

[2] Bureau of the Budget, Bulletin No. 60-6, p. 6.

[3] Garrity, p. 14.

failure to realize the potential of an automated information system is "the traditional tendency to focus on 'scrubbing up' the information already provided."[1] Data were not interrelated, and application of ADP merely extended the manual or tabulating procedures.[2] "Improved use of the computer is just beginning."[3] Mechanization of the present procedures is almost sure to be less efficient than procedures designed with the objectives of the organization and computer capabilities in mind.

Definition of the systems problem or objective in complete detail is not generally appreciated until delays and difficulties are met in converting to ADP.[4] While method analysis of any type requires defining of the problem, the detail of problem definition and the precision required in converting to automatic data processing are greatly increased. Problem definition requires: (1) explicit knowledge of the objectives, (2) diagram of the total process, (3) exact description of the output data and format, (4) exact description of the source data and format, (5) precise mathematical relationships of all data to be processed, (6) exact description of sequence of processing, and (7) exact description of exceptions and programs for dealing with them.[5] This detailed knowledge is necessary prior

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[1] Ibid.

[2] Neal J. Dean, "The Future of Electronic Data Processing," Financial Executive, XXXI, No. 6 (June, 1963), 39.

[3] Ibid.

[4] U. S. Comptroller General, Report to the Congress of the United States, Review of Automatic Data Processing System Used in Supply Management by the Department of the Navy, Aviation Supply Office, Philadelphia, Pennsylvania (Washington, D. C., 1962), p. 33. Cited hereinafter as Comptroller General, Review of Aviation Supply Office.

[5] Ibid.

to adapting the system to electronic data processing. Although the method of handling data in the Aviation Supply Office's electromechanical process was inadequate and required verification by manual methods prior to use of the data, this same method was incorporated into the automatic data processing system with the result that the new system's data also had to be manually verified prior to use.[1] The Aviation Supply Office officials planned to redesign their procedures and programs after the transfer to automatic data processing. Need for problem definition was recognized by the Aviation Supply Office officials in 1957 prior to the first computer installation, but even after two different computer installations, the problem had not been adequately defined.[2]

This discussion may seem to go to unnecessary length on the consideration of problem definition, but the number of computer installations which have not performed adequately due to failure to define the problem and to proceeding with a mechanization of existing procedures is large and costly. In the review of the Transportation Material Command, the General Accounting Office found, after expenditures of $300,000 for site preparation and $720,000 for rental of EDP equipment for two years, that the delay in filling requisitions more than doubled due to the failure to correct basic system weaknesses prior to converting to EDP.[3] Electronic data processing was used to speed up the old procedures but failed to take advantage of the machine capabilities in the General Services Administration

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[1] Ibid., p. 34.

[2] Ibid., p. 35.

[3] Comptroller General, Review of Transportation Material Command, p. 3.

installation in Kansas City.[1] In view of the Department Headquarters and the New York and Richmond Regional Offices of the Post Office, the General Accounting Office found that failure to determine its objectives through appropriate study and then selecting equipment to meet its requirements resulted in computer installations at three locations being removed as unsatisfactory.[2] In the 1960 review of ADP, the Comptroller General cited the failure to plan for integration of closely related procedures or poor systems planning as the reason for constant change in many ADP installations at a very high cost.[3] Once the objectives are defined, the next question to be answered is that of "What information is required to meet these objectives?"

Output Requirements and Specifications

Consideration of the output requirements and specifications includes a determination of type, volume, format, time required to prepare each transaction, frequency of preparation, and minimum time within which output should be processed.[4] One of the basic but hard decisions to make is distinguishing between the "required" information and the "nice-to-know" information. Looking at the old system tends to place much of the "nice-to-know" information in the "required" information category, but looking at the objectives tends to aid in segregating and eliminating much of the

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[1]U. S. Comptroller General, Report to the Congress of the United States, Review of Automatic Data Processing Activities of Selected Regional Offices, General Services Administration (Washington, D. C., 1962), p. 6. Cited hereinafter as Comptroller General, Review of Selected Regional Offices, GSA.

[2]Comptroller General, Review of Post Office Department, pp. 18-19.

[3]Comptroller General, Review of Developments, p. 10.

[4]Department of the Navy, Equipment Program, p. C-6.

"nice-to-know" information which probably costs more to generate than it is worth.[1] In considering the required information, external demands of higher authority for information and reports should be incorporated into the systems design, even if a request is made to modify or waive the external requirements.[2] Beginning with the information needs of the top executive of the organization and working down through each management level to determine the information needs is a recommended procedure in determining the required output. The decision that a certain kind of information is required makes further amplification necessary in order to develop specifications for the system desired. Distribution of the output and the form of distribution, i.e., printed report, magnetic tape, or punched cards, must be decided for each required output.[3] Number of copies, format of output, and recipients should be specified in detail and indicated on the flow chart of the new system. The daily, weekly, and monthly volume should be specified by type of output. Estimates of the time required to do each transaction and to produce the outputs should be included in the specifications of output. In their review of the Transportation Material Command, the General Accounting Office cited ineffective planning of output data as one reason for the inadequacy of the system.[4] The output data were "print outs" of all transactions in the computer, but management never used most of this information. Occasionally, "print outs" were used to check

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[1]F. F. Floyd, Personal interviews on Navy Aviation Maintenance and Material Management System, Department of the Navy, Washington, D. C., November and December, 1964.

[2]Department of the Navy, Data Processing Program, p. IV-6.

[3]Department of the Navy, Equipment Program, p. C-6.

[4]Comptroller General, Review of Transportation Material Command, p. 19.

the processing of the computer, but the computer could have been programmed to check itself. While unnecessary reports were generated, valuable information as to the activity of a particular item in inventory was not available in the output.[1] This failure to identify records and reports essential to the mission that can be processed by machine methods was also commented on by the General Accounting Office in their review at Fort Meade.[2] In this review the following was stated as a fundamental consideration:

> Those records and reports which are essential to the Army mission and which can be effectively processed by machine methods should be identified. Preliminary planning should be centered around the existing system. We believe it essential, however, that at the onset non-essential recordkeeping functions and reports be identified and eliminated from those to be processed by the ADP equipment. The content and quantity of records and reports which are to be processed should be accurately described. Likewise, limitations in machine processing should be recognized and records and reports which are not adaptable for machine handling should be excluded from the workload. Unless these things are done, a true evaluation of proposed conversion to an ADP system cannot be made and there can be no assurance that equipment selection will be made on a conservative and economical basis.[3]

After output requirements of the new system have been determined and formulated in specifications, analysis of the old systems output has the limited value of being a check to determine if information required in the new system has been omitted.[4] Once the specifications for output are

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[1] Ibid., pp. 19-20.

[2] U. S. Comptroller General, Report to Subcommittee No. 2, Select Committee on Small Business, House of Representatives, Review of Department of the Army Procurement of Automatic Data Processing Equipment, Fort Meade, (Washington, D. C., 1960), p. 19. Cited hereinafter as Comptroller General, Review of Fort Meade.

[3] Ibid.

[4] Department of the Navy, Data Processing Program, p. IV-6.

firm, the study can turn to the question of input.

Input Requirements and Specifications

Determination of the input required to produce the desired output includes specifications as to method of receipt of data, to format, to volume, and to rate of receipt.[1]

Input requirements may be readily determined by reference to output requirements, but placing emphasis upon the method of obtaining each needed item of basic or source data can result in an optimum method of obtaining source data.[2] Source data automation should be considered as it can result in substantial savings as well as reduce errors. A basic rule in determining input is that source data should only be introduced into the system once and should go through a verification process to insure accuracy and completeness of data. Determination of length, format, and other characteristics of the input such as alphanumeric capability will aid in selecting an appropriate computer.[3] "Alphanumeric" is defined as, "the characters which include the letters of the alphabet, numerals, and other symbols such as punctuation or mathematical symbols."[4]

Analysis of present inputs will aid in checking for omission of required inputs and in determining if all the required source data are available. If some of the required source data are not available, the system plan must include the procedure for making them available.[5] Once the

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[1]Department of the Navy, Equipment Program, p. C-5.

[2]Department of the Navy, Data Processing Program, p. IV-6.

[3]Department of the Navy, Equipment Program, p. C-5.

[4]Bureau of the Budget, ADP Glossary, p. 2.

[5]Department of the Navy, Data Processing Program, pp. IV-6, 7.

inputs are determined, they should be linked to the outputs in an outline of the system with sufficient detail to determine the feasibility of converting input to output.[1]

An estimate of the daily volume of input data and of any periods of peak loading is part of the input specifications.[2] A further estimate of the hourly rate at which the equipment can expect to receive the input should complete the input specifications, and brings up the closely related function of recordkeeping.

Maintenance of Information Requirements and Specifications

Maintenance of information is divided into five categories: alphanumeric requirements, length of records, volume of records, method of file maintenance, and interrogation requirements.[3] Each of these categories should be considered to determine the minimum specifications for the system. Alphanumeric requirements will generally be the same as specified for input. Record length, "the number of characters necessary to contain all the information in a record,"[4] can be proposed in the form of minimum, average, and maximum. Volume or number of records to be handled can also be estimated so that a range is proposed in the specifications. It should be kept in mind when determining requirements that there is a distinction between present requirements and expansion requirements; making this distinction

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[1] Ibid., p. IV-6.

[2] Department of the Navy, Equipment Program, p. C-5.

[3] Ibid., p. C-6.

[4] Bureau of the Budget, ADP Glossary, p. 30.

will aid in determining the size and type of computer to be acquired. In their review of Fort Meade, the General Accounting Office stated that a clear distinction should be made between basic requirements and expansion requirements.[1] "File maintenance" is defined as "the periodic modification of a file to incorporate changes which occur during a given period."[2] The method of file maintenance can be different for different applications and the cycle of updating the files should be dependent upon the urgency and value of current information. In their review of the Aviation Supply Office, the General Accounting Office cited the quarterly updating cycle or quarterly file maintenance cycle as too long a period because it did not meet the needs for current inventory information upon which to base purchasing decisions.[3]

Another consideration in maintenance of information is determining the requirements for interrogation of the stored information. The method of interrogation and time to retrieve the data should be estimated to complete the specifications for maintenance of information.

Data Handling Specifications

Data handling is defined as the manipulation of basic data in operation such as "classifying, sorting, calculating, summarizing, or recording," and data handling is synonymous with data processing.[4] Each type of transaction or computation that is required in data handling should be described in detail so that the problem may be properly assessed; but the

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[1]Comptroller General, Review of Fort Meade, p. 10.

[2]Bureau of the Budget, ADP Glossary, p. 31.

[3]Comptroller General, Review of Aviation Supply Office, p. 15.

[4]Bureau of the Budget, ADP Glossary, p. 40.

description should not prescribe how each transaction must be processed, because the selection of equipment would be prejudiced by a specific prescription of how the manipulation must be accomplished.[1]

Part of the data handling procedure should provide for a check on input data or for an initial editing operation for accuracy and completeness of data so that the input data will be free from errors.[2] Further requirements in this area are provisions for correcting erroneous data entered into the system, reentering of data rejected by the computer, and discovering the rare occasion in which information is garbled or destroyed by a faulty tape drive. In their review of the Aviation Supply Office, the General Accounting Office criticized the planning of the data handling and input for failing to:

1. Provide adequate checks to see that complete and accurate data were entered into the automatic data processing system.
2. Provide for entry, on a current basis, of changes in data having a direct bearing on the computation of needs such as changes in usage rates.
3. Provide for prompt correction and reentry of stock balance data which were rejected by the machine because of errors in the data.
4. Provide for integration of the various processes to be performed on automatic data processing equipment to prevent duplication of files and functions and minimize errors due to inconsistencies in the various files and functions.[3]

At this installation, the lack of a procedure for correcting errors in identification data and for timely entry of corrected identification data

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[1]Department of the Navy, Equipment Program, P. C-6.

[2]Lansdale Boardman, "Pitfalls in Planning Your Computer Installation," Financial Executive, XXXII, No. 8 (August, 1964), 10.

[3]Comptroller General, Review of Aviation Supply Office, p. 32.

resulted in manual correction procedures that took an average of seventy days to correct errors and as long as six months in some instances.[1]

Special Requirements and Specifications

Development of the specifications for the basic system may include requirements as to delivery date, maintenance, compatibility, and expansion.[2] Any requirement peculiar to the installation can be listed in the specifications along with other special requirements such as proposed delivery date and installation date. Consideration of the maintenance of equipment requires a decision as to the hiring of personnel to do the maintenance or contracting with the manufacturer for maintenance. Equipment compatibility is defined as,"the characteristic of computers by which one computer may accept and process data prepared by another computer without conversion or code modification."[3] Equipment compatibility with present equipment may be one of the requirements, but this decision should be weighed carefully, as the General Accounting Office has reported:

> Although replacement of a particular model of an ADP system by another model of the same manufacture may at times offer some advantages, evaluations of systems of other manufacturers could disclose overriding advantages in the form of lower cost and increased capabilities for meeting the needs of the user.[4]

A requirement for future expansion of capacity or extension of the system as part of an over-all plan should be included in the specifications,

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[1] Ibid., p. 25.

[2] Department of the Navy, Equipment Program, p. C-6.

[3] Bureau of the Budget, ADP Glossary, p. 12.

[4] U. S. Comptroller General, Report to the Congress of the United States, Review of Automatic Data-Processing Installation, New Orleans Commodity Office, Commodity Stabilization Service, Department of Agriculture October, 1959 (Washington, D. C., 1960), p. 15. Cited hereinafter as Comptroller General, Review of New Orleans Commodity Office.

but this future requirement should be clearly distinguished from the initial requirements. Including these special specifications with the specifications for data handling, information maintenance, input, and output should completely define the requirements of the system and the workload to be performed. The workload and specifications are complemented by the flow charts and organization charts of the proposed systems.

Two further fundamental considerations of planning for conversion to EDP stated by the Comptroller General were:

> 2. A practical system for collecting and storing data for making computations, and for preparing reports should be designed. The system should present an effective solution of the recordkeeping and reporting function for the installation without subordinating these requirements to the peculiarities of one or the other of available lines of equipment.
> 3. Equipment specifications should be prepared. Based on the requirements of the system, equipment specifications should be prepared to clearly define the characteristics and capabilities desired in the required equipment and to establish a practical basis for the competitive selection of ADP equipment.[1]

When the system study has been approved by higher authority, then the specifications can be submitted to all manufacturers of computer equipment with a view to receiving proposals of specific equipment configurations which can accomplish the tasks. The specifications must be sufficiently precise statements of the requirements so that varied interpretations will not be made by the manufacturers in submitting their proposals.[2]

"Systems specifications" is defined by the Bureau of the Budget as:

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[1]Comptroller General, Review of Fort Meade, p. 19.

[2]Ibid., p. 6.

(1) the delineation of the objectives which the system is intended to accomplish;
(2) the data processing requirements underlying that accomplishment, i.e., a description of the data output and its intended uses, the data input, data files, volumes of data, processing frequencies and timing; and
(3) such ADP equipment capabilities as may need to be identified.

Systems specifications will be designed to insure free competition among equipment manufacturers.[1]

Systems specifications serve as a basis for the selection of equipment and can be submitted to manufacturers as an invitation to submit proposals. Without detailed specifications, the assumptions by the manufacturers would vary in making the proposals, and there would not be a valid basis for making a comparison and evaluation of the various proposals. Soliciting proposals of all manufacturers capable of meeting the agencies' needs will aid in determining which equipment will be to the best advantage of the agency if the proposals are carefully analyzed in relation to cost and benefits.[2]

When the proposals are received, the systems study can proceed to the second stage, equipment selection and acquisition.

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[1]Bureau of the Budget, Circular No. A-54, p. 2.

[2]Comptroller General, Review of Kansas City and Evanston Commodity Offices, pp. 6-7.

CHAPTER V

EVALUATION AND SELECTION OF EQUIPMENT

Evaluation and selection of equipment is the second major stage of the systems study group's development of an electronic data processing plan, includes a comparative analysis of the proposed computer capabilities and of the advantages of the present and proposed systems, and is based on the criteria of capabilities, time, acceptability, and the total costs of each system.[1]

Although characteristics and capabilities of particular hardware have been in mind from the beginning of the preliminary study, the essential purpose of the evaluation and selection process is to insure the best interest of the organization. Equal information, opportunity, and facilities should be given to each potential supplier, and all qualified suppliers of equipment should be considered in order to obtain the best possible product.[2]

Of the various computers which can perform the task, the prime factors in determining the selection are time and cost. If time and cost are inclusive in determining the best model, then other factors may be considered. In preparing the time-cost estimates for potential equipment, the same work load and assumptions should be used in each estimate.

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[1]Bureau of the Budget, Bulletin No. 60-6, p. 8.

[2]Department of the Navy, Data Processing Program, p. IV-9.

Validation of work load and of assumptions in the manufacturer's estimates is only prudent.

Capabilities Criteria

In relation to the applications outlined in the specifications of requirements, the capabilities of the various computers can be divided into six areas of performance: data acceptance, capacity, processing, output form, controls, and suitability for long range plans. Detailed analysis of the proposed computers' ability should be made in relation to the specifications as to input documents and data so that inadequate, marginal, or adequate performance of input functions can be determined. Capacity for storage and for processing of each of the proposed computers should be analyzed in relation to the specifications to determine whether the capacities are inadequate, marginal, or adequate. Analysis of the data handling or processing ability should extend to each application planned and be evaluated in relation to the specifications so that a determination can be made that the proposed computers are capable of processing all of the planned applications. Analysis of output capability of each proposed computer should be sufficiently detailed to determine whether or not the computer can produce the required form of output. Accuracy and controls available with each proposed computer should be analyzed in relation to the specifications and planned applications in order to determine the adequacy of controls and accuracy. If a proposed computer does not meet the specifications and cannot perform the tasks, then it need not be considered any further. Capability in relation to long-range plans may also be significant in eliminating some proposed computers because they may not be adaptable to future plans.

The particular requirements and specifications developed in the system study must be examined in relation to the manufacturer's proposals in order to effectively evaluate the proposals.[1] There must be a direct correlation which shows that the equipment can be effectively adapted to the organization's needs. A Transportation Material Command study which set forth the data processing requirements for the organization and the workload statistics was deemed by the General Accounting Office as inadequate information to determine selection of particular ADP equipment because the detailed work load was not related to the machine capabilities.[2]

In another case, the officials of the New Orleans Commodity Office felt that the delay that would have resulted from a study to determine detailed specifications was too great, and they invited the two manufacturers of appropriate equipment to study the problem.[3] One manufacturer declined, and the other manufacturer's representatives joined the Commodity Office's employees in conducting a detailed study of a major work area.[4] Although this procedure was defended as combining the technical knowledge of a particular manufacturer with the experience of the agency personnel, the Comptroller General criticized the procedure because it did not explore the possibility that other manufacturers might be able to provide the same or more suitable equipment at a lower cost.[5] The Comptroller General specified that:

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[1]Comptroller General, Review of Fort Meade, p. 17.

[2]Comptroller General, Review of Transportation Material Command, p. 27.

[3]Comptroller General, Review of New Orleans Commodity Office, p. 4.

[4]Ibid., p. 11.

[5]Ibid., pp. 11, 16.

> It is most important that a decision to acquire or change a particular ADP system be made only after preparation of definite work specifications for the equipment and full consideration of the equipment of all manufacturers capable of meeting the agency's needs. The basis for any decision made should be properly documented in the agency's records.[1]

In the review of the Washington Regional Office of the General Services Administration, the Comptroller General criticized the specifications of procedures sent to the manufacturers because the specifications were generally the same as those used with their electromechanical equipment.[2] Further analysis of the proposed system resulted in development of additional procedural steps for the computer program at the Washington Regional Office, but the manufacturers solicited for proposals were not advised of the additional requirements. The additional procedural steps increased the estimated processing time on the equipment selected from four hours to sixteen hours per day. Further evaluation resulted in eliminating some of the procedural steps and changing some of the previously selected peripheral equipment. To meet the deadline set for starting computer operations, a substantial portion of the planned program was eliminated to fit the capabilities of the selected equipment. Forsseven months after installation of the equipment, the compiling and testing of programs were carried out, along with data conversion.[3] After one month of operation the programs were discontinued, and the equipment was later removed; the cost of planning, site

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[1] Ibid., p. 6.

[2] U. S. Comptroller General, Report to the Congress of the United States, Review of Planning for Automatic Data Processing Equipment, Washington, D. C., Regional Office, General Services Administration, October, 1961 (Washington, D. C., 1962), p. 6. Cited hereinafter as Comptroller General, Review of Washington Regional Office, GSA.

[3] Ibid., p. 7.

preparation, and consulting service was approximately $650,000.[1] This was a case in which the requirements were never known, and later efforts to adapt the limited capability of the selected equipment to modified requirements failed to achieve fruitful results. Only those computers which meet the specifications and are deemed capable of processing the workload should be evaluated on the basis of time.

Time Criteria

Time required to process all of the proposed applications can be divided into three areas: planned hours of usage, capability to meet requirements for processing cycles, and expansion potential. For each application or program an estimate should be made of the daily processing time that each proposed computer would take and should include all of the operations incidental to the processing.[2] This includes the average set-up time, which is defined as:

> the portion of elapsed time between machine operations which is devoted to such tasks as changing reels of tape, and moving cards, tapes, and supplies to and from the equipment.[3]

An estimate should be made of the average time of housekeeping operations which is defined as:

> A general term for the operation which must be performed for a machine run usually before actual processing begins. Examples of housekeeping operations are: establishing

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[1] Ibid., p. 4.

[2] Department of the Navy, Equipment Program, p. V-3.

[3] Bureau of the Budget, ADP Glossary, p. 58.

> controlling marks, setting up auxiliary storage units, reading in the first record for processing, initializing set-up verification operations, and file identification.[1]

Daily processing time estimates for each program on each proposed computer system should also include an estimate for program check-out and an allowance for re-runs. Without including the time estimates for incidental operations, the daily processing time for each program would be understated.[2] For each computer the daily time estimates for each program can be added to obtain an estimate of the average daily processing time.

If the system specifications prescribed a minimum elapsed time for certain functions, then the processing cycle times for those functions should be calculated in relation to the specifications to determine if any or all of the proposed computers can do the job. This same idea is present in specifications as to minimum interrogation cycles, which should be calculated for each computer to determine if it meets the specifications.[3]

Expansion potential of each proposed computer system can be partially determined by subtracting the total of average daily processing hours from twenty-four, but some reasonable allowance should be made for fluctuations in workload and for a possible underestimation of workload so that some additional capacity is available at the beginning.[4] If definite specifications have been made as to expansion capacity, then this characteristic of each computer must be evaluated.

Capability and time criteria have been well-documented in the General Accounting Office reviews, such as that of the Kansas City and Evanston

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[1] Ibid., p. 36.

[2] Department of the Navy, Equipment Program, p. V-3.

[3] Bureau of the Budget, Bulletin No. 60-6, p. 8.

[4] Department of the Navy, Equipment Program, p. V-5.

Commodity Offices and of the Transportation Material Command. Of four different computers installed at the Kansas City and Evanston Commodity Offices, insufficient use was made of the first system installed and two of the other three systems installed were inadequate for the purpose intended.[1] The General Accounting Office attributed these inadequacies to failure to consider the nature and amount of work in relation to equipment capabilities.

The General Accounting Office's review of the Transportation Material Command restated the requirement that the evaluation and selection of equipment must be based on an analysis of the equipment's ability to do the intended job and the time to do the job.[2] The workload of each program must be related to the capacity and speed of the computer under consideration in order to arrive at a valid estimate of the amount of total processing time to complete the total workload.[3] This requires the relating of the workload in detail to the speed and capacity of the particular machine; further guidance provided by the General Accounting Office was:

> Evaluation and selection of data processing equipment must be made in terms of a full analysis of the required criteria, including the following:
>
> 1. Capability of the machine to do the job:
>   a. Acceptance of input documents and data.
>   b. Sufficiency of storage and processing capacity.
>   c. Adequacy of data handling.
>   d. Production of output in required form.
>   e. Adequacy of controls and accuracy.
>   f. Adaptability of long range plans.

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[1]Comptroller General, Review of Kansas City and Evanston Commodity Offices, p. 5.

[2]Comptroller General, Review of Transportation Material Command, p. 41.

[3]Ibid., p. 13.

2. Time taken to do the job:
   a. Hours of use in relation to potential hours.
   b. Capability to achieve processing and interrogation (searching) cycles.
   c. Potential for expansion and mobilization needs.[1]

Estimates can be somewhat inaccurate but are poor when it is estimated that one computer will require eighty hours to do over thirteen million transactions and then later have two computers work one hundred twenty hours each and do less than two million transactions.[2] This means that with three times the estimated processing hours only one-tenth of the estimated data had been produced, or that only one-thirtieth of the estimated information had been processed within the originally estimated time. Errors of this magnitude can be avoided through planning which is done in extreme detail.

Acceptability

Acceptability of computer proposals relates to the availability of the computer on a given date and to the level of maintenance.[3] Manufacturers' proposals may be based on equipment which is under development and which may not be available by the desired delivery date. If a savings in cost is the basis for conversion to EDP, then the delay in delivery date should be reduced to the savings which will be foregone by not receiving delivery on the desired date. However, if the delivery date is a specific requirement due to urgency of objectives then the equipment not available by that date need not be considered.

The second aspect of acceptability is that of the adequacy of maintenance or level of maintenance. Costs of maintenance and repair are

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[1] Ibid., pp. 12-13.

[2] Ibid.

[3] Bureau of the Budget, Bulletin No. 60-6, p. 8.

important considerations in purchasing, but are generally included in the rental fee by the manufacturer.[1]

Location of the computer in a remote area may make in-house maintenance mandatory or less expensive. A contract for an adequate level of maintenance may be deemed necessary whether the equipment is purchased or leased. Considerations of cost have crept into the discussion of capabilities, but now the question turns to a cost analysis of the old system and the proposed computer systems to attempt to arrive at a cost/benefit analysis which will determine whether any computer system is worth the cost, and, if so, which computer system represents the least cost.

Advantage of a Computer

An economic or cost/benefit study should be made of the old system and of the proposed system in order to determine the advantages of using a computer; this cost/benefit analysis should include all of the initial costs of site preparation, programing, data conversion, training, parallel operations, and purchase of equipment, as well as the regular recurring costs of maintenance, rental, personnel, supplies, and utilities.

In comparing the old and the proposed systems, the Bureau of the Budget offered the guideline that as precisely as possible the advantages and disadvantages should be identified and described in relation to accomplishment of organization objectives. Experience with generalizations about the expected benefits, "such as better information, more data, faster processing" that were the basis for acquiring ADP equipment, reflected that these generalizations were not sufficient justification and did not necessarily result in an efficient installation.[2] An analysis of how automatic

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[1]Comptroller General, Review of Fort Meade, p. 10.

[2]Bureau of the Budget, Circular No. A-61, p. 5.

data processing would contribute to the accomplishment of objectives and of why automatic data processing is needed can help in appraising whether or not the proposed system is justified or is to be applied in the "most potentially fruitful or significant application."[1] Advantages generally fall into the three categories of timely production of data, data not previously available, and economy.[2] Production of data that were not previously available, or doing "things that couldn't be done under older methods within a reasonable time or cost limitation," is the most significant advantage of the computer.[3] Although these intangible benefits are not often reducible to dollar figures, "they represent the real payoff from having a computer."[4] Benefits derived from an ADP installation may be in technical and scientific areas and result in an increase in costs rather than in a cost reduction.[5] Although analysis of the intangible benefits to management is difficult, the estimates of costs of converting to ADP are not so difficult except for the tendency to overlook cost items and to underestimate all costs.

Cost Analysis

Comprehensive cost studies are essential in making the decision to convert to or modify automatic data processing systems. The costs of

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[1] Ibid., pp. 4-5.

[2] Bureau of the Budget, Bulletin No. 60-6, p. 8.

[3] Schlosser, p. 548.

[4] Ibid.

[5] Comptroller General, Review of Geological Survey, p. 11.

operating under the present system should be compared with the estimated costs of operations under an electronic data processing system.[1] Systems improvements which can be made without conversion to EDP should be identified separately, and savings due to these systems improvements should not be attributed to the use of ADP. This distinction is important in weighing the economic advantages of EDP.[2] Underestimation of the costs involved has been repeatedly experienced in the development of ADP installations, and this underestimation has been mainly due to failing to include some important cost elements in conversion.[3] Consideration of each of the principal cost elements in relation to each manufacturer's proposal of equipment deemed to be capable of fulfilling the requirements should be made to determine which computer represents the least total cost and to determine the total cost against which to weigh the benefits of the proposed system.

Site Preparations

At a minimum, site preparation costs include remodeling of buildings, installation of power cables, additional power generators, raised flooring to cover machine cables, soundproofing, air-conditioning and humidity controls,[4] and site preparation may include the rental or purchase of a building and land. According to the Bureau of the Budget, site preparation costs may range from $20,000 to $150,000 or more.[5] For site

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[1] Comptroller General, Review of Kansas City Evanston Commodity Office, pp. 7-8.

[2] Ibid., p. 38.

[3] Bureau of the Budget, Circular No. A-61, p. 5.

[4] Comptroller General, Survey of Progress, p. 64.

[5] Bureau of the Budget, Circular No. A-61, p. 5.

preparation of large computer installations, the Air Force had an average cost of $130,000.[1] Site preparation for large computer installation in the Army had an average cost of $275,000, while the Navy experienced an average cost of $80,300.[2] Site preparation costs have been as high as $465,000 and did not include the purchase of land or a building.[3] Estimates of the site preparation costs should be amortized in preparing the forecast of costs in order to obtain a longrun projection of costs.[4]

Another principal cost element is that of preinstallation analysis and programing. This cost element for large computer installations in the Air Force had an average cost of $97,000.[5] Preinstallation analysis and programing for large computers had an average cost of $111,000 in the Army installations, and an average cost of $93,700 in Navy installations.[6] Program development not only includes the program for each application but the dictionary, directory, and other procedural manuals as well. The dictionary is the standardized "list of code names used in a routine or system and their intended meaning in that routine or system."[7] The directory is a file which describes the layouts of each type record.[8] Among other procedural manuals are those that include precise, step-by-step directions for running

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[1]Comptroller General, Survey of Progress, p. 82.

[2]Ibid., pp. 100, 111.

[3]Ibid., p. 100.

[4]Comptroller General, Review of Post Office Department, p. 26.

[5]Comptroller General, Survey of Progress, p. 82.

[6]Ibid., pp. 100, 111.

[7]Bureau of the Budget, ADP Glossary, p. 18.

[8]Ibid., p. 19.

each application including checks and tests. Although preparing the procedural manuals is time-consuming, the manuals are a means of achieving standardization which is a necessity in computer operations. In considering the various manufacturer's proposals, differences in the availability of "software," that is, developed programs and routines that can be used in the system, and differences in programing assistance offered, should be reduced to dollar values so that the costs of each system are comparable.[1]

Data Conversion and Purification

Closely associated with programing costs are the costs of converting the existing records and reports into a form suitable for use by automatic data processing equipment and for data purification. Data purification is defined as "the reduction of the number of errors as much as possible prior to using data in an automatic data processing system."[2] A data purification campaign should be conducted with the initial conversion of existing records to a form suitable for ADP equipment because the information which comes out of the computer is only as good as the basic input. An International Business Machines Corporation executive expressed the problem as "How can you expect to get gospel out, if you put garbage in?"[3] In the Air Force installation, the rate of error per record ranged from seven percent to twenty-eight percent. The cost to purify sixty-five percent of 170,000 documents was $94,690.[4] In the Army installations, the rate of error per record ranged from five to over one hundred percent in one case,

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[1]Department of the Navy, Data Processing Program, p. IV-10.

[2]Bureau of the Budget, ADP Glossary, p. 43.

[3]Marvin Kornbluh, Presentation in International Business Machine Customer Executive Program, Washington, D. C., January 26, 1965.

[4]Comptroller General, Survey of Progress, p. 66.

completely new source data were obtained because the existing files were so poor.[1] Navy's experience in data purification was an error rate per record of one-tenth of one percent at the Aviation Supply Office as reported in the 1957 survey.[2] However, subsequent review of the Aviation Supply Office revealed a large percentage of errors in the basic files, part of which may have existed during conversion.[3]

Training

Another principal cost is that of training of personnel. Although no cost figures were given, it was stated that "large scale efforts and costs" were involved and that an average of 250 hours of formal training followed by three months to three years on-the-job training was required before significant contributions to operations were made by systems analysts, programers, operators, and supervisors.[4] Staffing for computer installations in the Air Force and Army ranged from five to eighteen operators and twenty to ninety-nine analysts and programers, and about an equal number of systems research personnel, supervisors, tape librarians, administrative personnel, control clerks, and auxiliary electromechanical operators.[5] Staffing for the Navy's large computer installations ranged from a total of seventy-three to one hundred seventy-four personnel in all phases of the installation.[6] In considering the training offered in the

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[1] Ibid., p. 91.

[2] Ibid., p. 105.

[3] Comptroller General, Review of Aviation Supply Office, pp. 22, 34.

[4] Comptroller General, Survey of Progress, pp. 64, 82.

[5] Ibid., pp. 68, 93.

[6] Ibid., p. 105.

various manufacturers' proposals, any differences in the amount of training offered and in distance to the training facilities should be reduced to dollar values so that the total costs of the various proposals are comparable.[1]

Parallel Operations

A significant cost can be attributed to parallel operating, which is the operating of both the old and new systems until the ability of the new system to satisfactorily perform the workload is determined. Although testing and "debugging" of the programs are started as early as possible, it is during the conversion period that testing and "debugging" are completed. Debugging is defined as locating and correcting any errors in the computer program or computer itself.[2] Eleven to thirty-one percent of the time in the first year of operation was required by program testing and debugging in the Air Force.[3] Program testing and reruns due to errors consumed from thirty to forty-three percent of the available machine hours in Army installations in the first four to eleven months of operation.[4]

Computer and Peripheral Equipment

A major cost element is that of the computer itself and of all the peripheral equipment for the system. The variety and possible combinations of equipment available may appear to be an exercise in combinations and permutations, but this number will be greatly reduced by the manufacturer's proposals. However great the manufacturer's knowledge of his own equipment may be, this does not relieve the prospective purchaser from evaluating some

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[1]Department of the Navy, Data Processing Program, p. IV-10.

[2]Bureau of the Budget, ADP Glossary, p. 16.

[3]Comptroller General, Survey of Progress, p. 67.

[4]Ibid., p. 91.

basic considerations in costing out each proposed configuration of equipment. Capacity and speed of a given computer may not leave sufficient processing time for expansion of applications if used on only one shift, but if planned for a two-shift operation the same computer may more than meet the requirements. Planning for the use of more than one shift of operation gives much greater flexibility in the amount of peripheral equipment which is needed. As the General Accounting Office review of the New York and Richmond Post Offices noted, use of more than one shift should be explored to increase economy of operations.[1] Use of one piece of equipment on two shifts rather than two identical pieces of equipment on one shift will reduce purchase or rental costs.[2] Later, the Comptroller General reported that "equipment capacity on hand and paid for but not used is an irrecoverable loss."[3] A schedule to obtain "maximum use from a minimum number of machines" will help prevent purchase or lease of excess capacity.[4] Initial planning could be for the use of the computer itself on a two-shift operation and use of peripheral equipment on one, two, or three shifts depending on the need for and speed of equipment. Initial planning which includes utilization of the computer itself on three shifts would probably not allow "a reasonable balance of utilization and reserve capacity for future expansion."[5]

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[1]Comptroller General, Review of Post Office Department, p. 22.

[2]Comptroller General, Review of Kansas City and Evanston Commodity Offices, p. 10.

[3]U.S. Comptroller General, Report to the Congress of the United States, Review of the Problems Relating to Management and Administration of Electronic Data Processing System in the Federal Government (Washington, D. C., 1964), p. 4. Cited hereinafter as Comptroller General, Review of Problems.

[4]U.S. Comptroller General, Report to the Manpower Utilization Subcommittee, Committee on Post Office and Civil Service, House of Representatives, Investigation of Allegations Pertaining to Waste and Mismanagement in the Statistical Services Operations, Warner Robins Air Material Area, Robins Air Force Base, Georgia (Washington, D. C., 1959), p. 7. Cited hereinafter as Comptroller General, Review of Robins Air Material Area.

[5]Department of the Navy, Data Processing Program, p. IV-10.

Not only are the amount and scheduling of equipment important but the manner in which the equipment works with the computer must be considered. Use of on-line equipment may give greater flexibility in operations, but on-line equipment, such as card readers, printers, and card punchers, increase the time required for operation of the computer. In the New Orleans Commodity Office, use of magnetic tape for voluminous input and output from the computer and use of off-line card readers, printers, and card punchers would have greatly increased the speed of the total operation and reduced the expense of the operation.[1] If only a small amount of information is needed during the processing, such as discovery of errors or exceptions, the console typewriter is sufficient for on-line reporting and the high speed printer is more efficient as off-line equipment. Off-line equipment can be connected so that its use as on-line equipment, if deemed necessary for a particular operation, can be accomplished by merely turning a switch on the console.[2]

Compatibility with other equipment can be overstressed as a factor in the acquisition of new equipment but should be just another cost factor since peripheral equipments are available by which any one equipment can be made compatible to any other.[3]

Computation of the cost of initial stocks of reels of magnetic tape, storage cabinets, punch cards, and other supplies for each proposed computer system should complete the estimates of initial costs, and then the recurring cost of operation can be considered.

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[1]Comptroller General, New Orleans Commodity Office, p. 7.

[2]Ibid., p. 30.

[3]Department of the Navy, Data Processing Program, p. IV-10.

Maintenance

Maintenance costs for each proposed computer can be taken from the manufacturer's proposal, unless maintenance is to be performed by the staff. An estimate for cost of spare parts should be made, and the staffing increased to cover the added workload, if maintenance is to be performed by the staff. One to five percent of the total available machine hours were consumed by unscheduled maintenance periods in Air Force installations as reported by the General Accounting Office.[1] Since maintenance is generally provided as part of rental charges, if the equipment is leased, the maintenance costs should be added to the purchase price when making a comparison between the relative advantages of purchasing or leasing. One of the notions which seemed prevalent about leasing was that the quality of the maintenance while leasing would be superior to the manufacturer's contract maintenance for a purchased computer, but the General Accounting Office found that they could not distinguish the quality of maintenance provided under a leasing agreement from the quality of maintenance provided under a maintenance service contract.[2]

Purchase or Lease

Resolving the question of whether to purchase or lease the equipment should be based upon a comparative cost analysis that a cost advantage will occur within six years and that the equipment will continue to satisfy the system's requirements beyond the cost advantage point. The foregoing

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[1]Comptroller General, Survey of Progress, p. 67.

[2]U. S. Comptroller General, Report to the Congress of the United States, Study of Financial Advantages of Purchasing Over Leasing of Electronics Data Processing Equipment in the Federal Government (Washington, D.C., 1963), p. 35. Cited hereinafter as Comptroller General, Purchasing Over Leasing.

criteria were reemphasized in Bureau of the Budget Circular A-61[1] but were criticized by the General Accounting Office in that the particular organization making the decision may not be able to use the equipment for five or six years, but that the equipment could be used thereafter by some other organization within the same agency or other agency of the government.[2] It was further pointed out that most computers are general purpose in nature and can be used in less demanding areas if critical defense or national interests require the latest equipment.[3] Experience has shown that most data processing equipment, including the vacuum tube or first generation computers, has been utilized for five to ten years; the second generation computers have a considerably longer, useful life.[4]

Bureau of the Budget Circular A-54 stated that in the comparative cost analysis of methods of acquisition that purchase costs should include "purchase price, maintenance, and other one-time costs applicable only to purchase" and that the allowance by the manufacturer for trade-in could be used as a "representation of the residual value" of the equipment to the government.[5] This view of residual value was contested by the Comptroller General, who stated that commercial trade-in values are not the proper measure of residual value and that residual value is more properly determined by dividing the purchase price by the total years of useful service.[6] This

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[1]Bureau of Budget, Circular No. A-61, pp. 12-13.

[2]Comptroller General, Purchasing Over Leasing, p. 12.

[3]Ibid., p. 13.

[4]Ibid., p. 15.

[5]Bureau of the Budget, Circular No. A-54, p. 4.

[6]Comptroller General, Review of Problems, p. 24.

method results in a residual value to the government rather than to the particular organization at which the equipment will be located. The foregoing argument would be just as valid for large corporations as it is for the government; whereas, quoted commercial trade-in values would probably be the best measure of residual value to smaller corporations. But even the computer manufacturers have recently revised their schedules of determining the sales price of leased, installed equipment from a deduction of ten percent per year with a maximum discount of seventy-five percent of the original sales price to the new deduction of five percent per year for the first four years and ten percent thereafter with a maximum discount of thirty-five percent of the original sales price, no matter how old the equipment. This revision in the discount available under a lease with-option-to-purchase shows an apparent increase in residual value and tends to support the Comptroller General's contention that even after use for three or four years the residual value of equipment would be in excess of fifty percent of the original purchase price.

The factors used in determining purchase price by the General Accounting Office were purchase price, maintenance costs, and interest on both maintenance costs and purchase price (interest rate was average rate on outstanding debt); while the factors used in determining leasing costs were rental charges and interest on rentals.[1] For a large number of installations total cost of purchase was compared with the total cost of rental for a five-year period, and as a result the General Accounting Office concluded that if purchasing is financially advantageous, savings increase with increased

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[1]Comptroller General, Purchasing Over Leasing, pp. 15, 18.

utilization (such as two or more shifts), and that the larger and more complex the computer the more pronounced the savings.[1]

It was also recommended that separate costing of each component of the system should be made in arriving at the decision to purchase or lease because some units such as electromechanical components are more expensive to purchase because of pricing policies of the manufacturer and of increased maintenance costs due to the wearing of moving parts.[2]

Possibility of technological obsolescence is one of the main justifications used for leasing rather than purchasing equipment.[3] However, justification generally cannot be found for the high costs involved in redesign of the system, reprograming, site modifications, and retraining associated with a change of equipment.[4] "The freedom to engage in frequent modernization of equipment, which rental arrangements are purported to provide, is often more apparent than real."[5]

When purchase is not fully justified in the cost analysis or when there is no previous experience with which to establish the validity of the systems design, a lease with an option to purchase would be the preferred method of acquisition.[6] The least desired method of acquisition is the plain lease, which would be used when neither of the other two methods could be justified. Typical examples of comparative costs of the methods

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[1] Ibid., pp. 24-25.

[2] Ibid., p. 23.

[3] Comptroller General, Review of Problems, p. 19.

[4] Bureau of the Budget, Circular No. A-61, p. 13.

[5] Ibid.

[6] Bureau of the Budget, Circular No. A-54, p. 4.

of acquisition are Attachments A and B of Bureau of Budget, Circular No. A-54.

If the decision is made to acquire the equipment under any form of lease agreement, a good feature to have included in the equipment is a meter to record the time which the equipment is used. As much as ten to thirty percent of the time recorded by manual methods for overtime utilization of rented equipment was in error when checked against automatic time meters.[1] This meter is more accurate than the most efficient manual recording methods for maintaining computer use time records and will help prevent overpayments for leased equipment. Variations in contractual terms offered by suppliers should be reduced to estimated dollar values so that the total price for each system will be comparable with each other.

Personnel

Staffing represents a significant part of the recurring cost of operation, and the cost of staffing requirements includes consideration of the number and level of employees as well as employee benefits. In Air Force installations, the average number of analysts and programers was twenty-nine, and the government service grade level ranged from five to thirteen (with an annual salary from $3,670 to $10,710), while the number of operators ranged from five to eighteen, with lower grade levels for programers and analysts.[2] In Army installations, the government service grade level of systems analysts, programers, and operators was respectively, eleven to thirteen (with an annual salary range of $6,390 to $10,710, five to

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[1]Comptroller General, Review of Problems, p. 4.

[2]Comptroller General, Survey of Progress, p. 68.

eleven, and four to eleven (with an annual salary range of $3,415 to $6,390).[1] About an equal number of additional personnel was required in the various duties of systems research, tape librarians, auxiliary equipment operation, and administration. In two large Navy ADP installations, the number of employees was seventy-three and one hundred seventy-four, but the number in each functional job was not given.[2] The salary for these levels was not sufficient to prevent a high turnover rate in skilled personnel in some of the Air Force, Army, and Navy installations.[3] Later raising of the grade levels for analysts, programers, and operators reduced the retention problem, and the salaries for each grade level in the government service are now over thirty-three percent higher than those of 1957.

Substantial underestimation of the number of personnel required for their EDP installation was cited as a major reason for the underestimation of annual operating costs of the New Orleans Commodity Office.[4]

Consideration of the costs of annual leave, retirement, and insurance payments is necessary to prevent underestimation of the personnel costs. Failure to consider the costs of these benefits as well as underestimating the number of personnel required contributed to the sizeable underestimation of annual operating costs in the New Orleans Commodity Office.[5]

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[1] Ibid., pp. 92-93.

[2] Ibid., pp. 105-106.

[3] Ibid., pp. 68, 93, 106.

[4] Comptroller General, Review of New Orleans Commodity Office, p. 42.

[5] Ibid.

Major Supplies and Utilities

An estimate of the recurring costs of major supplies such as magnetic tape and punch cards, and utilities required for each proposed computer system, will complete the lists of costs, which will allow a selection of the equipment with the least cost and required capabilities.

Least Total Costs

After all of the foregoing analysis of capabilities and costs of various computers is completed, a decision can be made to select the computer which can meet the system's requirements and which represents the least cost of all the capable computers. An adequate study should meet the fourth fundamental consideration, stated by the Comptroller General, which is:

> 4. An economic evaluation of the conversion to an ADP system should be prepared. Equipment should be selected and a reasonably firm understanding should be reached with the manufacturer as to the cost for equipment to be used, maintenance, facility and utility requirements, and personnel requirements. These data should be used in preparation of the economic evaluation. The economic evaluation should clearly define the conversion period and conversion cost as well as the cost of operation before and after conversion.[1]

Although there is no "policy which simultaneously maximizes gain and minimizes cost,"[2] the analysis of the various costs of each computer should reveal which computer can perform the job for the least total cost.

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[1]Comptroller General, Review of Fort Meade, p. 19.

[2]Charles J. Hitch and Roland N. McKean, The Economics of Defense in the Nuclear Age (Cambridge: Harvard University Press, 1961), p. 165.

Much of this discussion has progressed from point to point and stage to stage on the assumption that the results of each study and investigation has resulted in the conclusion that the benefits from the utilization of automatic data processing equipment would outweigh the costs or would be worth further investigation. However, if at any stage the study group comes to the conclusion that the benefits of electronic data processing are not sufficient to justify the cost, this conclusion should be reported to the top manager. Even if acquisition of equipment is not justified, potential savings may be found in having records, such as personnel, payroll, and accounting, processed by a commercial electronic data processing service firm or by renting computer time from another firm. For Federal Government agencies, the sharing of computer facilities offers an inexpensive means of acquiring computer service, if there is another government agency in the area with computer time available. This sharing will increase the utilization of the installation and help prevent unnecessary duplication in a given area. Even if the computer is rented, the cost of the additional time would be only forty percent of the base rate (the rate charged for the first 176 hours per month) and only for the time used.[1] Federal Government agencies can contact the General Services Administration for information on computer sharing exchanges, which are being promoted in metropolitan areas and where a concentration of agencies exists.[2] The General Services Administration may also be able to furnish the Federal Government agencies which are considering an ADP system with information as to other agencies which

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[1]Bureau of the Budget, Circular No. A-61, p. 9.

[2]U. S. Bureau of the Budget, Policies and Responsibilities on the Sharing of Electronic Computer Time and Services in the Executive Branch, Bureau of the Budget, Circular No. A-27 (Washington, D. C., 1964), p. 3.

have developed and operated a similar ADP system.[1] Establishment of a central applications file is under consideration by the Bureau of the Budget, but until a decision on this is announced, the General Services Administration may be able to provide the information desired. Lack of a central information center and authority to exercise control over new applications of EDP within all of the Federal agencies has been recurring criticism by the Comptroller General.[2]

The Bureau of the Budget receives reports on utilization and costs incidental to the operation of all ADP systems in the Federal Government, and the reports of the same type computer system and applications as comparisons.[3] If the utilization of EDP is recommended and a computer is selected, the final step in planning is the development of a time schedule.

Schedule for Conversion

A time schedule of all of the significant steps and work to be accomplished in converting to EDP will assist in transition as well as aid in later evaluation of the installation. All of the previously considered cost factors of site preparation, preinstallation analysis and programing, data conversion and purification, selection and training of personnel, installation of equipment, and parallel operations should be worked into a conversion schedule so that the time required to complete each factor is considered and the interdependence of factors can be established. Knowledge obtained in the cost analysis should be beneficial, but a shortcoming

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[1]Bureau of the Budget, Circular No. A-61, p. 8.

[2]Comptroller General, Survey of Progress, p. 28; Review of Developments, p. 46; and Review of Problems, p. 7.

[3]U. S. Bureau of the Budget, Annual Reports on the Utilization of Automatic Data Processing Equipment in the Executive Branch, Bureau of the Budget, Circular No. A-55, Schedules A. and B.

which is generally present in the cost estimates is also generally present in the time estimates—under-estimation. The time required for training systems analysis, and programing is generally underestimated significantly. Site preparations can be scheduled to be completed before the proposed delivery date, but even this is not always well-scheduled.[1] Experience has shown that,

> with few exceptions, the initial plans establishing the delivery date for the ADP system were overly optimistic. Less emphasis on early delivery of the equipment and more emphasis on problem definition and its solution would result in speeding up the effectiveness of the system when it is installed.[2]

The real heart of establishing a fixed delivery date appears to be having a sufficient amount of programing completed so that utilization for production can begin shortly after installation rather than being almost completely devoted to testing and debugging. Excess rental charges were incurred on electromechanical equipment because of delay in converting to EDP on one program for nine months and on another for nineteen months.[3] Similar cases of having equipment installed before sufficient programing has been completed to effectively utilize the equipment within a short period seem endless.[4] Although a tentative date is scheduled for installation of

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[1]Comptroller General, Survey of Progress, p. 100.

[2]Ibid., p. 83.

[3]U. S. Comptroller General, Report to the Committee on Post Office and Civil Service, House of Representatives, Review of Selection and Utilization of Automatic Data-Processing Equipment, National Institutes of Health, Public Health Service, Department of Health, Education, and Welfare, September 1959 (Washington, D. C., 1960), pp. 13-14.

[4]Comptroller General, Review of Post Office Department, pp. 32, 34; Review of New Orleans Commodity Office, p. 5; Review of Transportation Material Command, p. 25; and Review of Kansas City and Evanston Commodity Offices, p. 20.

equipment, a firm date of installation should not be determined until sufficient programing is completed to effectively utilize the equipment; if a firm date is established and subsequent events show the delivery date to be unrealistic, renegotiation of the delivery date should be attempted, especially if the equipment is to be rented.[1]

Another aspect of scheduling the installation of equipment when sufficient programing of the workload has been completed is that the claims of the manufacturer for performance can be validated shortly after installation.[2] The length of time required for completion of a systems study generally takes four to eighteen months, followed by eight to eighteen months for equipment delivery.[3] Planning for installation was started six years in advance in an insurance firm and three years in advance in Michigan Bell Telephone Company.[4] In complex, decentralized operations, two to five years are needed to plan for and to complete the transition from a manual system to an integrated automatic data processing system.[5] The results of planning were well-expressed by the General Accounting Office when it reported:

> In our review of selected activities, we have found that the degree of success in working with electronic systems is directly related to the amount of preplanning and study that has been undertaken before the equipment is acquired.[6]

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[1]Bureau of the Budget, Circular No. A-61, p. 15.

[2]Comptroller General, Review of Fort Meade, p. 19.

[3]Bureau of the Budget, Circular No. A-61, p. 9.

[4]Julius Rezler, "Managerial Functions in the Era of Automation," Advanced Management Journal, XXIX, No. 2 (April, 1964), p. 59.

[5]Fisch, p. 15.

[6]Comptroller General, Review of Developments, p. 13.

CHAPTER VI

EVOLVING ROLE OF PLANNING FOR EDP

The role of planning in converting to electronic data processing has been increasing exponentially in breadth as to the broad areas of the management setting of which it is a part and in depth as to every significant and insignificant detail of the organization to which it is to apply. The initial step in planning is the defining of the objectives in relation to the multiple roles which any organization must play in its complex environment. Objectives such as making a profit or providing a service are almost no statement of objectives at all. When the objectives are defined as a certain amount of profit in given fields or the quantity and quality of types of services to be rendered, the objectives become specific enough to be clarified and sub-goals and policy established. This is a part of the broad aspects of planning for conversion to electronic data processing because it is in relation to these objectives, sub-goals, and policies that each function, process, and action is measured later in the detailed analysis. If the organization undertaking the planning is a unit within a larger organization, the objectives and goals of the larger organization must be considered if a satisfactory solution to the subsidiary organization's objectives is to be meaningful and lasting. Even where there is no hierarchial level above the organization doing the planning, the organization must set its objectives with a view to the society of which it is a part. The needs of the larger organization are superimposed on the units

which are a part of it, especially in the area of information. The life-blood of control and direction is the information which flows to those in authority and the reverse flow of information for redirection or correction.

Automatic data processing holds the promise of simplifying decision-making but, at the same time, makes decision-making more complicated than ever. Through the application of the principle of management by exception, EDP can eliminate the drudgery of wading through masses of information to find the significant data upon which to act, but at the same time this very principle requires that a determination be made as to what data shall be reported to the system and what standards will be set so that only significant deviations will be reported. The apparent freedom imposes a correlative duty which entails planning of a very significant degree. The possibilities of integration of functions, not only within a decentralized unit but within a vast, sprawling organization, appear to be effectively limited only by the ingenuity of systems analysts and management engineers, who are repeatedly bettering their past performance and achieving more optimum organization patterns and information systems. Attempting to implement a revolutionary concept in an evolutionary manner holds all the comforts associated with the security of a slow change but has a price tag of a slow implementation of a laborsaving, more efficient device. The capabilities of the computer are so much greater and more far-reaching than any other device previously available to management that a basic shift in management's methods, procedures, and organization is necessary to realize the potentials of the new device. Centralization of functions and decisions has been greatly facilitated. The old adage of allowing the decision to be made at the place where the problem existed was based on the idea that where the

problem existed so also the information existed. Now the potential exists that if the information is available at any level, it can be placed in a central bank of information so that any level can draw on it to make or evaluate a decision. The hard decisions are still hard decisions, but they can be based on much more information if adequate planning has been completed.

The crux of the problem is in defining objectives and sub-goals so that standards can be set for performance, and the information necessary to evaluate performance is generated and stored with significant deviations being reported when it deviates significantly from the standard. The integration of the various units of an organization into one information system is a very complex planning problem. But now the potential exists for control of an extremely large organization if adequate planning is completed as to the information required and the standards to which the management by exception principle will be applied.

The movement towards centralization of functions and control of the agencies in the Federal Government will be greatly speeded up when a central information authority is appointed to coordinate information on and to approve EDP systems within the executive branch of the Federal Government. When this central authority is designated, the movement for standardization of information systems will increase and further complicate the planning for conversion to EDP. Planning will be moved to a much higher level within the Federal agencies and tend to be on an agency-wide level, which will increase the amount of centralizing of functions within

the agencies. As more and more information is available to those higher in the hierarchy, they will make more and more of the decisions previously made at lower levels.

Centralized direction and control of data processing are essential in an integrated information system, but in an organization as large as the Federal Government centralized direction and control can easily fail to recognize the needs of small segments of the agencies. The present policy of planning and developing EDP installations within each agency at the level of use of the EDP installation is slowly moving to planning at a very high level for an information system to apply to an entire agency in certain functional areas. Justification for centralized direction and control is that standardization is necessary to merge the separate information systems into an agency-wide information system and to avoid duplication of reporting as well as duplication of planning and development. The cost and length of time involved in the long-range planning for complex computer installations are becoming so large that avoiding duplication of development studies represents a real saving. This saving can be maximized under centralized direction of information systems development and appears to outweigh the disadvantages of relieving the user of this authority. Allowing each user to develop his own system has resulted in a vast amount of duplication of effort and has not necessarily resulted in the user's being able to determine his own needs better than anyone else. Under centralized direction the users at all levels should participate in the planning for an integrated system, just as representatives of each functional part of an organization should assist in the planning when conducted solely by

the user organization to insure that all needs and prospective programs are considered.

Planning under centralized control will assist in maintaining the interests of the total organization but in no way does this mean that the planning is less detailed. Unlike normal long-range planning, planning for an integrated information system requires planning in extreme detail for each and every level and user. Each user's needs should be considered in developing the system, methods, and procedures. This type of planning requires a shift in knowledge, principles and methods.

While attempting to keep in mind the broad objectives of the organization, the very detailed analysis of each facet of the organization questions the why and worth of everything. This apparent contradiction in viewpoint, seeing the total picture while carefully analyzing each minute detail by itself and in its relationships to other minutiae, is the goal of the systems study for an integrated information system. The requirement for examination and evaluation of every detail has escaped the top managers in many instances and has been the basis of recurring problems as conversion to electronic data processing is attempted.

Writers have tended to oversimplify the complexities of reducing information to meet the narrow machine logic required by computers and the complexities of reducing the human logic involved in business decisions to quantitative terms for the computer instructions. Everything must be planned for the computer, including the exceptions, if the computer system is to work satisfactorily. Examination of every detail and planning for a system to process the required information take such a long period of

time and cost so much that top management is apt to be impatient in waiting for results.

Many of the studies of computer installations have reflected a concentration on getting the system installed and doing something, rather than a concentration on detailed analysis of requirements. Concentration on expediting the installation has generally resulted in much higher costs and forced an eventual return to detailed system analysis and reprograming to solve subsequent shortcomings and oversights. There is no substitute for the planning required for a successful application of electronic equipment to an information system; the planning may finally be done after repeated failures or problems develop but will eventually be done, as planning is a condition precedent to a satisfactory application.

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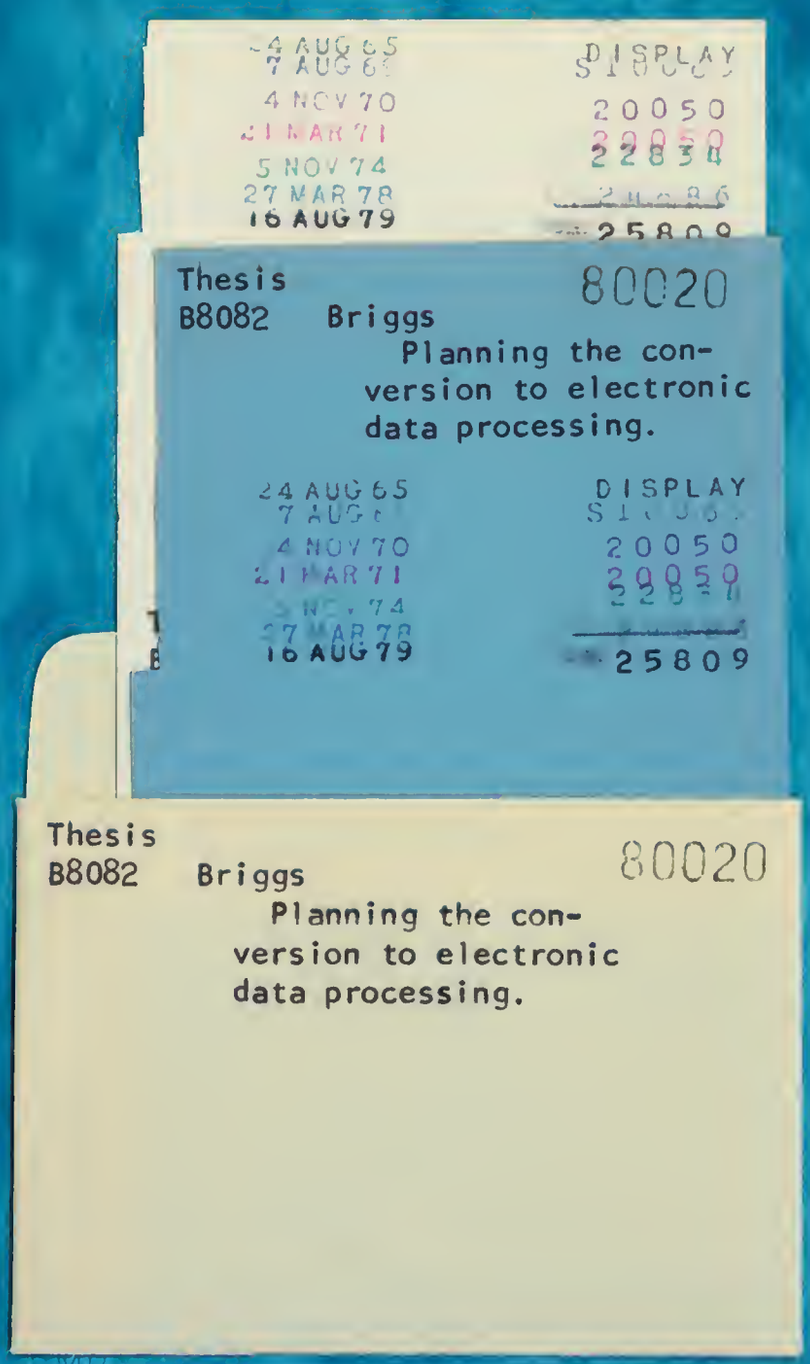
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